



Containment Accident Pressure Committee

Task 5 – Effects of Non-Condensable Gases on Seals (CVDS Pump)

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Executive Summary

This BWROG Technical Product provides an evaluation of the effect of non-condensable gases which come out of solution and migrate to a pump seal purge piping. The evaluation is based on the seal purge piping arrangement of the Monticello RHR pump (model CVDS).

Implementation Recommendations

This product is intended for use to address (in part) issues raised in the NRC Guidance Document for the Use of Containment Accident Pressure in Reactor Safety Analysis (ADAMS Accession No. ML102110167). Implementation will be part of the BWROG guidelines on the use of Containment Accident Pressure credit for ECCS pump NPSH analyses.

Benefits to Site

This product provides a technical response to the NRC concerns raised in the reference document above about the potential pump seal damage resulting from gases which come out of solution and migrate into the pump seal purge piping.



QUALITY LEVEL

- ☐ Direct
☐ Indirect

SULZER PUMPS (US) INC. DOCUMENT

DOC. NO: E12.5.1913
ORDER NO:

TITLE: Task 5 – Effect of Non-Condensable Gases on Seals
Sulzer Pumps (US) Inc.
Monticello - 12x14x14.5 CVDS RHR Pump

ASME CODE
SECTION

CLASS NO.

CODE EDITION
(YEAR)

SEASON
YEAR

CUSTOMER GE-HITACHI Nuclear Energy Americas LLC

PROJECT Monticello Nuclear Power Station, Monticello, MN

CUSTOMER P.O. NO. 437054820

CONTRACT NUMBER

SPECIFICATION NO. _____

ITEM / TAG NUMBER

CUSTOMER APPROVAL NUMBER:

SPACE FOR CUSTOMER APPROVAL STAMP
(when applicable/available)

CUSTOMER APPROVAL REQUIREMENT

☐ Yes ☐ No ☒ Information Only

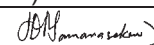
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APPROVALS (SIGNATURE)

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Engineering



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Quality Assurance

CERTIFICATION (when applicable)

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Professional Engineer

State

Registration No.

Date _____

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Dept: Advance Engineering

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Date: 11/7/2011

APPLICABLE S.O. NUMBERS:
100072780

E12.5.1913

0
Rev.

DOCUMENT IDENTIFICATION

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1.0 PURPOSE

The purpose of this report is to evaluate the potential impact of the evolution of non-condensable gases on the mechanical seals of Monticello RHR pumps.

2.0 BACKGROUND

Dissolved gases are present in water depending on the fluid temperature, gas solubility, pressure, and duration of contact. For extended time duration, the gas and liquid will come to an equilibrium state according to Henry's Law. As a liquid passes through a centrifugal pump, the reduced pressure at the pump inlet can result in some of the dissolved gas coming out of solution as gas bubbles. Since the pump seals are continuously cooled using flush water from the pump discharge, the flush water will contain small amounts of gas bubbles. In addition, it is also possible that air bubbles can migrate within the pump casing into the pump seals.

3.0 SCOPE

The following are evaluated in this report.

- Froude number and critical flow calculation are used to determine the possibility of bubble accumulation in the discharge end and mechanical seal piping.
- Mechanical seal flush piping orientation, seal flush, and internal bearing flush injection system's role in permitting entrained air to accumulate in the stuffing box region of the pump.

4.0 ANALYSIS

This report evaluates the potential for the accumulation of the non-condensable gases at the mechanical seal faces that could cause the lack of lubrication and cooling of the seal faces leading to damage and eventual seal failure. To predict gas accumulation it is important to understand the piping configuration and the flow characteristics of the two-phase (liquid along with the entrained gas) fluid. Figure 1 shows examples of two phase flows. The Froude number, a ratio of inertial force on a liquid to gravitation force, is a useful parameter for predicting non-condensable gas dynamics in a fluid carrying duct.

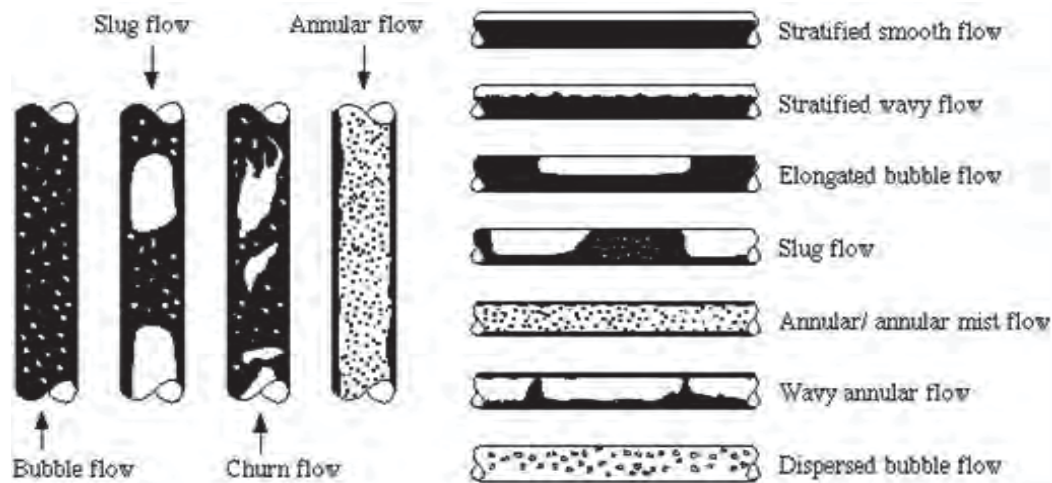


Figure 1: Entrained Air in Pipes [Ref 1]

4.1 According to BWROG, The suppression pool water is normally at a range of [[]] to [[]] and is at equilibrium with the suppression pool air space, which is composed of [[

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4.2 In the case of the Monticello RHR pumps the mechanical seals are lubricated and cooled by pumpage (flush) that is tapped off from the discharge nozzle (See Fig. 2). Water at high pressure enters the cyclone separator where any debris in the flush is separated out. A Froude number calculation for the discharge and the seal piping can show if the bubbles trapped in the fluid will travel through the mechanical seal flush piping and reach the internal bearings. It is important to note that;

$$Q_c = 0.38 \times (D)^{\frac{5}{2}} \times g^{\frac{1}{2}} \quad \rightarrow \text{Equation 2 [4]}$$

Where,

D = Pipe ID, in

g = 32.2 ft²/sec

Using the above equation, critical flow for the discharge piping equals [[]] and for the seal piping [[]]. Hence, blockage of flow due to bubble accumulation is possible if flow rate in the discharge piping falls below [[]] or below [[]] in the seal piping. The expected flow through the discharge piping is [[]] and seal piping is [[]], both of which are well above the critical flow values.

- 4.3 After passing through the mechanical seal flush piping, entrained air would reach the internal bearings. However, due to the vertical orientation of the pump and the seal, the less dense entrained air entering from point A (See Fig 3) would rise up in the stuffing box outlet to connection point B located above the seal faces and exit to the pump suction. Arrows (Fig 3) show anticipated bubble flow path.
- 4.4 As long as the flush flow is above the critical flow, the possibility of air accumulation in the seal piping is not present. Also, stagnation or accumulation of air around the seal faces is unlikely due to the orientation of the seal and the location of the stuffing box outlet B. Therefore, due to the above reasons the likelihood of the seals running dry is negligible.

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Figure 2: Monticello - RHR Mechanical Seal Layout

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Figure 3: Mechanical Seal Connections

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5.0 RESULTS AND CONCLUSIONS

Two methods; Froude Number and Critical Flow calculations indicate that air bubbles will not stagnate and accumulate in the seal piping. The vertical orientation of the pump and the location of the flush inlet and outlet on the seal stuffing box significantly reduce the possibility of air accumulation in the vicinity of the mechanical seals.

Some of the concerns, regarding air entrainment in mechanical seals, raised in the NRC guidelines can be addressed through this report.

- a) Entrained air released due to NPSH margin reduction – As explained in this report, the vertical setup of the mechanical seal system will flush out the bubbles, and therefore, as long as a minimum flow through the mechanical seal piping is maintained, the possibility of void fraction accumulating at the seal faces is negligible.
- b) Use of Dual Mechanical Seals – For a vertical mechanical seal setup with seal flush outlet located at the top of the seal, dual mechanical seals with external flush system will not provide an additional benefit. Vertical setup ensures constant flushing of the seal faces.
- c) Excessive entrained air centrifuged inward to the shaft – Forced lubricated bearings are located between the impeller inlet and the mechanical seals. This high pressure liquid will prevent any bubbles to flow from the impeller inlet to the mechanical seal faces.

Therefore, the entrained air that may be present in the suction line of the RHR pumps following a LOCA has no significant impact on the performance of the mechanical seals.

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